INDOOR AIR QUALITY ASSESSMENT

Amvets Boulevard Elementary School
70 Amvets Boulevard
North Attleborough, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Roland Denault, Buildings and Grounds Administrator for the North Attleborough Public Schools (NAPS), the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Amvets Boulevard Elementary School (ABES) in North Attleborough, Massachusetts. The indoor air quality assessment was prompted by symptoms that occupants attributed to environmental conditions in the building. On May 12, 2004, a visit to conduct an indoor air quality assessment was made to this school by Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Mr. Holmes was accompanied by Steve Hagerty, Head Custodian, during portions of the assessment.

The ABES is a one-story brick building constructed in 1961, originally as a junior high school. A modular classroom was added in the early 1990s, and the roof to the main building was replaced during the 2003-2004 school year. The school contains general classrooms, music room, art room, gymnasium, cafeteria, auditorium, library and office space. Windows are openable throughout the building.

Methods

BEHA staff performed a visual inspection of building materials for water damage and/or microbial growth. Moisture content of water-damaged building materials was measured with a Delmhorst, BD-2000 Model, Moisture Detector equipped with a Delmhorst Standard Probe. Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The ABES houses approximately 400 kindergarten through fifth grade students and approximately 65 staff members. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in twelve of twenty-one areas surveyed, indicating inadequate ventilation in a number of areas. Mechanical ventilation equipment was deactivated in many areas on the day of assessment. It is also important to note that several classrooms with carbon dioxide levels below 800 ppm were unoccupied or sparsely populated, which can greatly reduce carbon dioxide levels. Therefore during full occupancy the carbon dioxide levels would be expected to be higher.

Fresh air in classrooms is supplied by a unit ventilator (univent) system (Figure 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building (Picture 1) and return air through an air intake located at the base of each unit. Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Univents have local controls for "low" and "high" fan speed (Picture 2). The majority of univents were deactivated during the assessment, preventing a mechanical means to introduce air into the building (Table 1). Obstructions to airflow, such as items on and/or in front of univents were seen in a number of classrooms (Picture 3). The air intake on the exterior of classroom 15 was completely obstructed with plywood (Picture 4). In order for univents to provide fresh air as designed, these units must remain "on" and allowed to operate while these rooms are occupied. Importantly, intakes, diffusers and returns must remain free of obstructions.

Mechanical exhaust ventilation in classrooms is provided by unit exhaust ventilators (Picture 5). A unit exhaust ventilator appears similar to a univent, but removes air from the classroom and pushes it out of the building (Picture 1). Unit exhaust ventilators were not operating at the time of the assessment and appeared not to have been operating for some time. BEHA staff examined the interior of several of these units and found units were deactivated or motors were unplugged (Picture 6). Mr. Haggerty plugged in the unit exhaust ventilator in classroom 13 and the unit reactivated. Without proper supply and exhaust ventilation, normally occurring environmental pollutants can build-up and lead to indoor air quality/comfort complaints.

Ventilation for the modular classroom is provided by AHUs mounted on the exterior of the building. Fresh air is distributed to the classroom via ductwork connected to ceiling-mounted air diffusers. Return vents draw air back to the AHUs through wall-mounted grilles. A thermostat controls the heating, ventilating and air conditioning (HVAC) system and has fan settings of "on" and "automatic". The thermostat was set to the fan "on" setting during the assessment, which is recommended by BEHA. The "automatic" fan setting on the thermostat activates the HVAC system at a preset temperature. Once the preset temperature is reached, the

HVAC system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system.

In order to have proper ventilation with a mechanical supply and exhaust system, these systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see Appendix A.

Temperature readings ranged from 70 ^{o} F to 80 ^{o} F, which were above or close to the upper end of the BEHA comfort guidelines in a number of areas surveyed. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. A number of temperature control complaints were reported. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In addition, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents deactivated/obstructed, unit exhausts deactivated).

Relative humidity measurements ranged from 48 to 58 percent, which were within the BEHA comfort range. The BEHA recommends that indoor air relative humidity be maintained in a comfort range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

The building has a history of roof leaks, which led to the aforementioned roof replacement. A number of areas had water-damaged ceiling tiles, which is evidence of historic roof or plumbing leaks. Water-damaged ceiling tiles can provide a source of mold growth and should be replaced after a water leak is discovered and repaired.

BEHA staff were asked to examine carpeting in the library. The carpet is reportedly moistened periodically. In order for building materials to support mold growth, a source of moisture is necessary. Identification and elimination of water moistening building materials is necessary to control mold growth. Building materials with increased moisture content over normal concentrations may indicate the possible presence of mold growth. Identification of the location of materials with increased moisture levels can also provide clues concerning the source of water supporting mold growth. In this case the most obvious source of moisture was a roof drain, as evidenced by a water stain located directly below it (Picture 7).

In an effort to ascertain moisture content of carpeting in the library, measurements were taken directly below the roof drain. A number of non-effected areas of the library carpet were measured for comparison. A Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe was used to ascertain moisture content. The probe was inserted into the surface of carpeting. The Delmhorst probe is equipped with three lights that are visual aids for determining moisture level. Readings that activate the green light indicate a sufficiently dry level (0 - 0.5%); those that activate the yellow light indicate borderline conditions (0.5 – 1.0%) and those that activate the red light indicate elevated moisture content (> 1%).

Elevated moisture content was measured in carpeting directly beneath the drain (Picture 8/Table 1). At the time of the assessment, BEHA staff recommended removing/replacing this section of carpeting and inspecting the roof drain for proper drainage. In a subsequent conversation with Mr. Denault, it was reported that the section of water-damaged carpet would be removed and replaced with tile prior to the beginning of the 2004-2005 school year. The US

Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

Plants were observed in several classrooms. Plants, soil and drip pans can serve as sources of mold growth. Plants should be properly maintained, over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plants in one classroom were located on top of paper towels (Picture 9). Paper towels are a porous material that can provide a medium for mold growth, especially if wetted repeatedly.

Plants and shrubbery were also observed in close proximity to univent air intakes on the exterior of the building (Picture 10). Plants should be located away from ventilation sources to prevent aerosolization/entrainment of dirt, pollen or mold.

Other Concerns

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured in the school were also ND.

As previously mentioned, the US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations the day of the assessment were measured at 53 $\mu g/m^3$. PM2.5 levels measured indoors ranged from 8 to 54 $\mu g/m^3$, which were close to or below the background level (Table 1). Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC measurements throughout the building were also ND.

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use TVOC containing products. While no measurable levels of TVOCs were detected, materials containing VOCs were present in the school. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Several other conditions that can affect indoor air quality were observed during the assessment. Of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate (Picture 11). These items, (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Dust can be irritating to the eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

A number of univents had accumulated dust, cobwebs and debris within the air handling chambers (Picture 12). These conditions may be attributed to non-continuous equipment operation, which allows airborne particulates to settle within the units. In order to avoid this equipment serving as a source of aerosolized particulates, these units should remain activated and the air handling sections should be regularly cleaned (e.g., during scheduled filter changes). Several classrooms also contained personal fans. Accumulated dust was seen on the blades of fans (Picture 13), which can be reaerosolized during operation.

In an effort to reduce noise from sliding chairs, tennis balls had been cut open and placed on chair legs (Picture 14). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off-gas VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998).

Conditions in classroom 21 may attract rodents. Stored food containers, presumably to be used for art projects were seen (Picture 15). Under current Massachusetts law (effective November 1, 2001) the principles of integrated pest management (IPM) must be used to remove pests in state buildings (Mass Act, 2000). Pesticide use indoors can introduce chemicals into the indoor environment that can be sources of eye, nose and throat irritation. Steps to reduce/eliminate pathways/food sources that can attract pests should be taken.

Several areas had portable air purifiers. The air purifier in classroom 11 was located on the floor near the hallway door. These units are normally equipped with filters that should be cleaned/changed as per the manufacturer's instructions. In addition, these units are designed to strain particulates from airflow and would be more beneficial if relocated off the floor in the breathing zone.

Finally, exposed pipe insulation was observed on pipes in the rear of univent cabinets (Picture 16) that may contain asbestos. Upon discovery, these findings were reported and shown to Mr. Hagerty for more immediate attention. BEHA staff recommended that the material be inspected and encapsulated by a licensed member of the NAPS maintenance staff or other professional contractor as soon as practicable. BEHA staff subsequently contacted Mr. Denault, who reported that the pipe insulation was encapsulated.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Inspect all univents to ensure exposed/damaged pipe insulation material around univent pipes is encapsulated/remediated in conformance with all applicable Massachusetts' laws.
2. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers throughout the school.
3. Operate all ventilation systems that are operable throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy and independent of thermostat control. To increase airflow in classrooms, set univent controls to "high".

4. Continue to operate modular classroom thermostat in the fan "on" setting during occupancy to provide continuous air circulation.
5. Inspect exhaust motors and belts for proper function. Repair and replace as necessary.
6. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
7. Consult a ventilation engineer concerning re-balancing of the ventilation systems. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994).
8. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
9. Ensure all roof leaks are repaired. Continue with plans to replace the section of water-damaged carpet in library and any remaining water-stained ceiling tiles. Examine the areas above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
10. Consult "Mold Remediation in Schools and Commercial Buildings" published by the US EPA (2001) for further information on mold. Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html.
11. Vacuum interior of ventilation units during regular filter changes or more frequently if needed to prevent the aerosolization of dirt, dust and particulates.

12. Clean personal fans periodically of accumulated dust.

13. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

14. Clean filters for air purifiers as per the manufacturer's instructions or more frequently if needed. To enhance airflow relocate air purifiers from off of the floor.

15. Consider discontinuing the use of tennis balls on chair legs.

16. Use the principles of integrated pest management (IPM) to prevent pest infestation and rid the building of current pests. A copy of the IPM recommendations can be obtained from the Massachusetts Department of Food and Agriculture (MDFA) website at the following website: http://www.state.ma.us/dfa/pesticides/publications/IPM_kit_for_bldg_mgrs.pdf. Activities that can be used to eliminate pest infestation may include the following:

    a) Avoid using food as components in student artwork.
    b) Rinse recycled food containers. Seal recycled containers in a tight fitting lid to prevent rodent access.
    c) Remove non-food items that rodents may consume.
    d) Store foods in tight fitting containers.
    e) Avoid eating at workstations. In areas where food is consumed, vacuum periodically to remove crumbs.
    f) Clean crumbs and other food residues from ovens, toasters, toaster ovens, microwave ovens, coffee pots and other food preparation equipment on a regular basis.

g) Examine each room and the exterior walls of the building for means of rodent egress and seal. Holes as small as ¼" are enough space for rodents to enter an area. If doors do not seal at the bottom, install a weather strip as a barrier to rodents. Reduce harborages (e.g., cardboard boxes) where rodents may reside (MDFA, 1996).

17. Consider adopting the US EPA (2000b) document, Tools for Schools, for self-assessments and practices for maintaining good indoor air quality environment at your building. The document is available at http://www.epa.gov/iaq/schools/index.html.

18. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website: http://www.state.ma.us/dph/beha/iaq/iaqhoFtme.htm.

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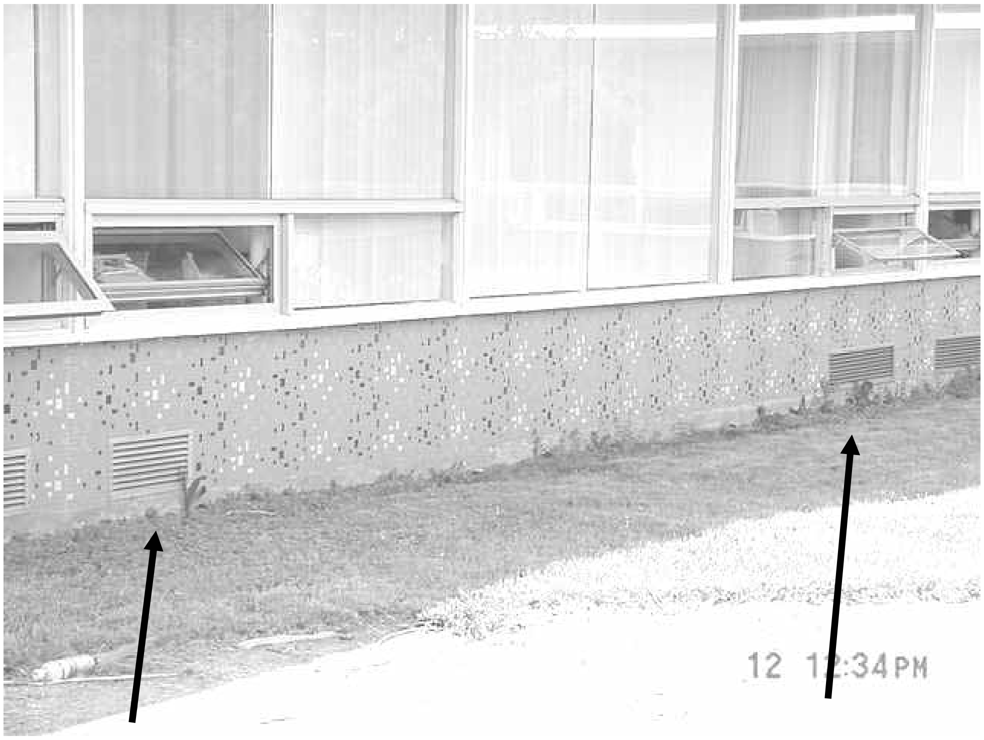
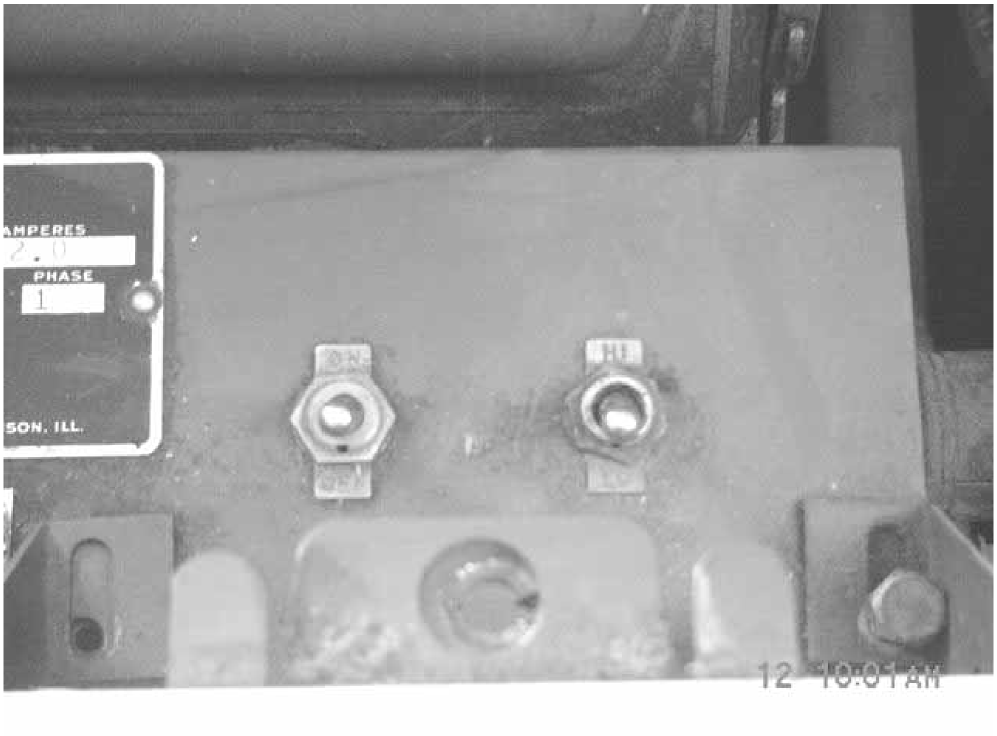
Picture 1



exhaust vent **fresh air intake**

Air Intakes and Exhaust Vents for Classroom Univents and Unit Exhaust Ventilators

Picture 2



Toggle Switches for Activation of Univents (Left) and Fan Speed Control (Right), Note Univent is Deactivated

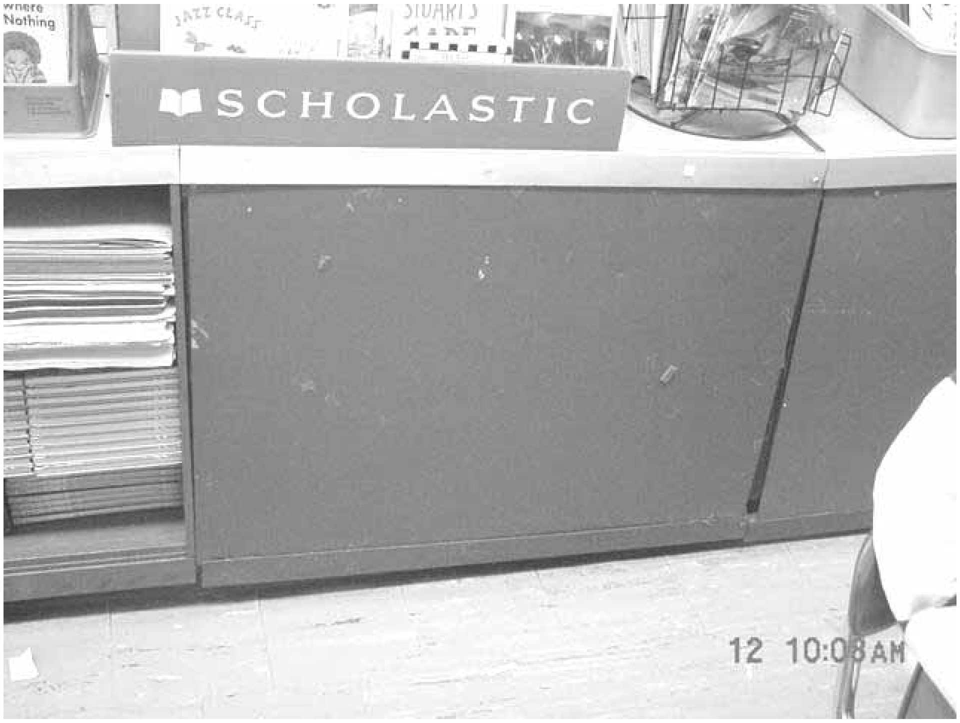
Picture 3

Univent Obstructed by Items on Top and in Front of Return Vent

Picture 4

Univent Fresh Air Intake Blocked by Plywood

Picture 5



Unit Exhaust Ventilator in Classroom

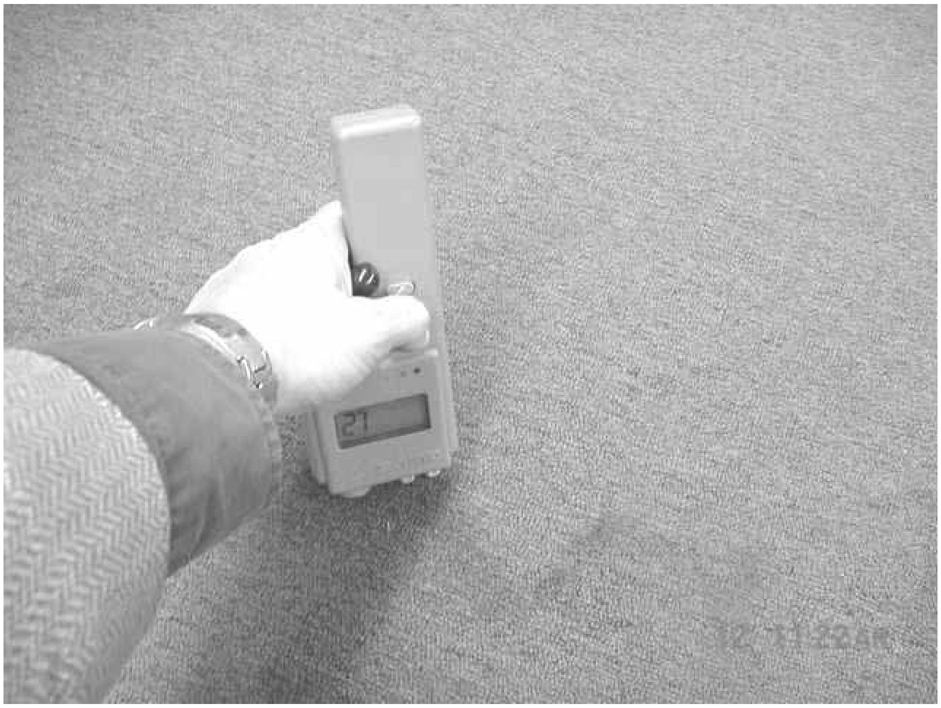
Picture 6

Mechanical Components (fans, motor, etc.) of Unit Exhaust Ventilator

Picture 7

Roof Drain and Water Damaged Carpet in Library

Picture 8

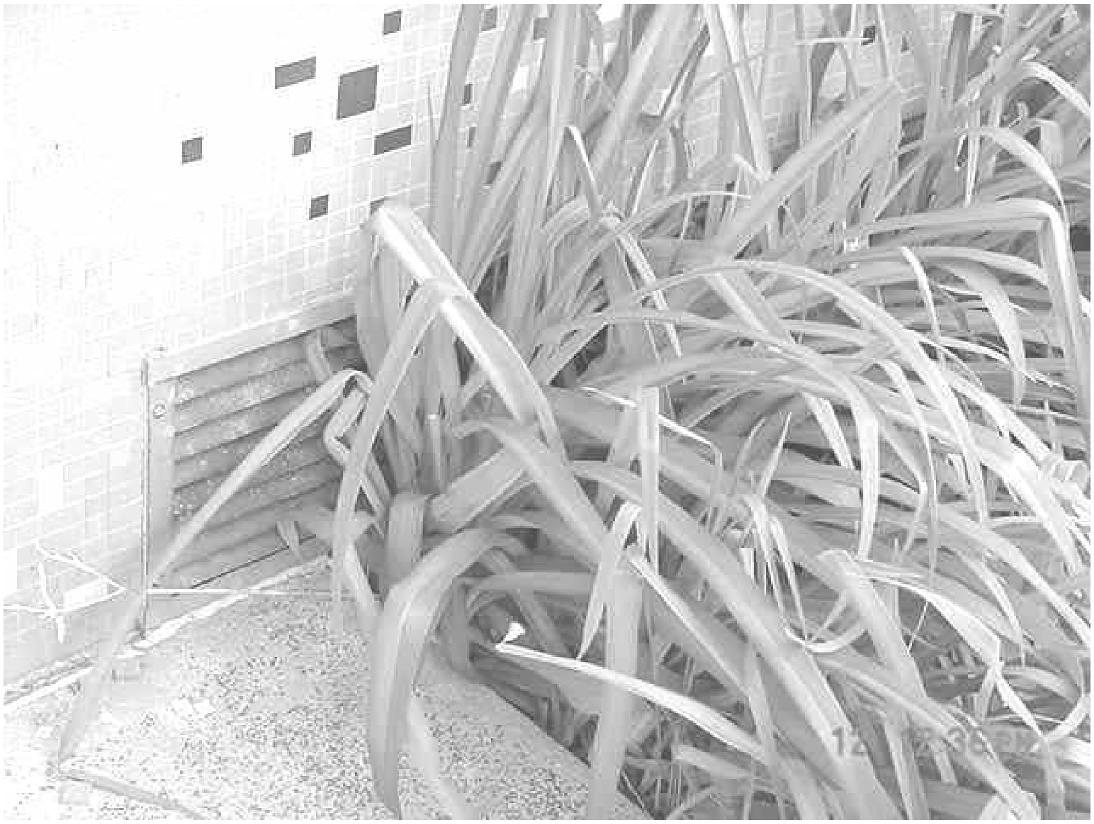


Water Damaged Carpet with Elevated Moisture Content in Library

Picture 9

Plant on Saturated Paper Towel in Classroom

Picture 10

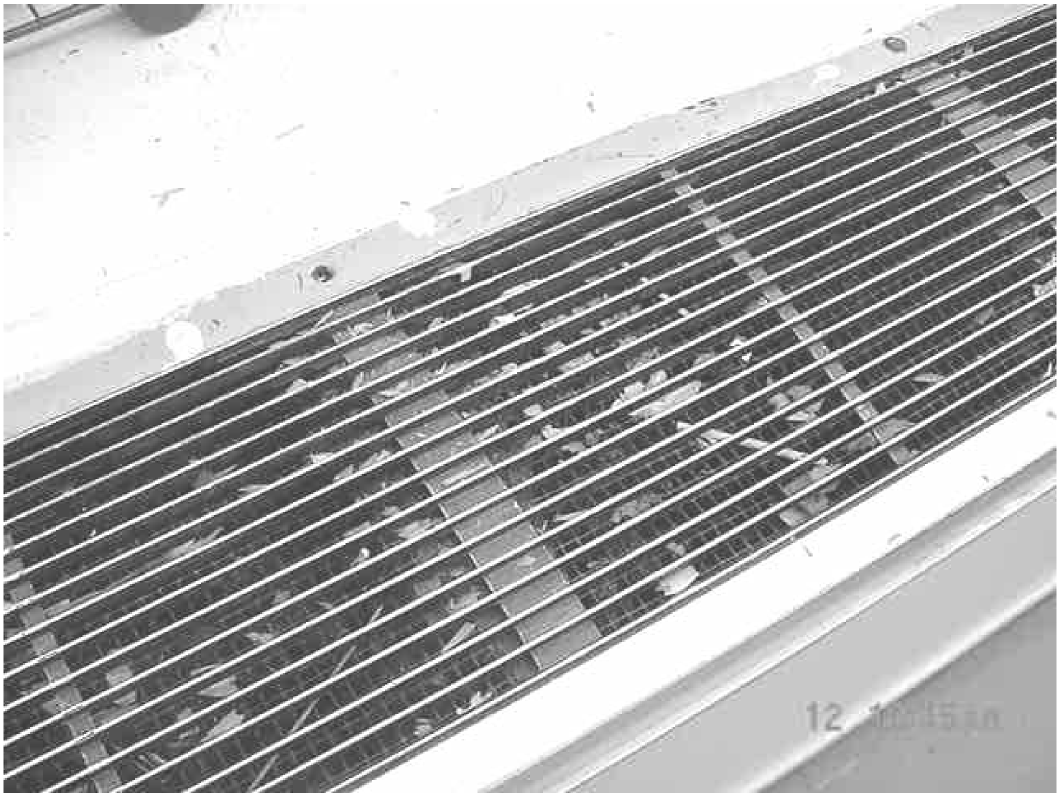


Plants in Close Proximity to Univent Air Intake

Picture 11

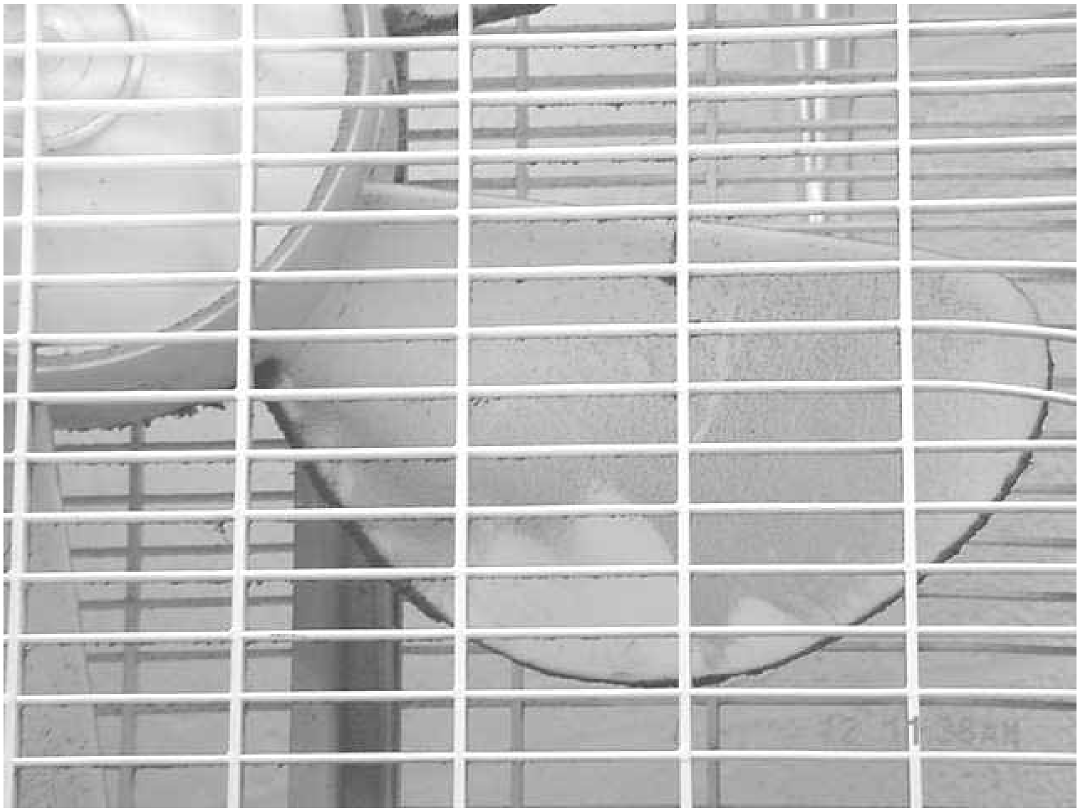
Accumulated Items in Classroom

Picture 12



Debris in Univent Air Diffuser

Picture 13



Accumulated Dust on Fan Blades

Picture 14

Tennis Balls on Chair Legs in Classroom

Picture 15

Empty Egg Containers in Classroom 21

Picture 16

Exposed Insulation Material around Univent Pipes in Rear of Cabinet

Amvet Boulevard Elementary School **Indoor Air Results**

Amvet Boulevard, North Attleboro, MA 02760 **Table 1** **May 12, 2004**

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background (Outside)	77	55	425	ND	ND	53	-	-	-	-	Overcast, winds light and variable
Auditorium	76	52	558	ND	ND	48	21		Y Off Ceiling	Y Off Ceiling	Exterior door open
Main Office	77	54	666	ND	ND	48	5	Y	N	N	PC; hallway door open; AC
1	79	52	605	ND	ND	46	1	Y	Y Off UV	Y Off UE	Hallway door open; AC; supply blocked by clutter
5	79	56	839	ND	ND	48	21	Y	Y Off UV	Y Off UE	DEM, PF, plants; hallway door open
4	79	56	1189	ND	ND	41	22	Y	Y UV	Y Off UE	Exposed insulation material UV pipes; odor from UV
2	80	48	822	ND	ND	39	21	Y	Y Off UV	Y Off UE	DEM; hallway door open; wall mounted AC

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium
AT = ajar ceiling tile

BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
design = proximity to door
FC = food container

FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile
NC = non-carpeted
ND = non detect

PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium

UE = unit exhaust
UF = upholstered furniture
UV = univent
WP = wall plaster
WD = water damage

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Amvet Boulevard Elementary School

Amvet Boulevard, North Attleboro, MA 02760

Table 1

Indoor Air Results

May 12, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
10	77	51	544	ND	ND	40	0	Y	Y Off UV	Y Off UE	DEM, TB; window AC; plants on paper towel
13	78	54	514	ND	ND	47	16	Y	Y UV	Y Off UE	DEM, PF; hallway door open; unit exhaust unplugged; plugged in to reactivate by custodian
14	78	50	471	ND	ND	44	1	Y	Y Off UV	Y Wall	DEM; hallway door open; 22 occupants gone ~20 min., UV deactivated
11	77	55	983	ND	ND	50	24	Y	Y Off UV	Y Off Wall	AP, DEM, clutter; hallway door open; air purifier near hallway door on floor
Cafeteria	77	54	884	ND	ND	52	~90	Y	Y UV	Y Off Wall	Hallway door open, 2 of 3 “On”; Exhaust off
8	79	58	965	ND	ND	51	22	Y	Y UV	Y Off Wall	DEM; hallway door open
21	77	57	1239	ND	ND	54	0	Y	Y Off UV	Y Off UE	DEM, aqua/terra, food use/storage, plants; hallway door open; egg cartons

ppm = parts per million
µg/m3 = micrograms per cubic meter
AD = air deodorizer
AP = air purifier
aqua. = aquarium
AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials
design = proximity to door
FC = food container
FCU = fan coil unit
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile
NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings
sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UE = unit exhaust
UF = upholstered furniture
UV = univent
WP = wall plaster
WD = water damage

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Amvet Boulevard Elementary School | **Indoor Air Results**

Amvet Boulevard, North Attleboro, MA 02760 | **Table 1** | **May 12, 2004**

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
15	78	58	635	ND	ND	44	20	Y	Y Off UV	Y Off Wall	Hallway door open
16	78	49	1000	ND	ND	41	1		Y Off UV	N	DEM; hallway door open; 20 occupants gone 1 hr.
17	78	58	696	ND	ND	46	18	Y	Y Off UV	N	DEM; hallway door open; UV reactivated by custodian
Library	77	46	750	ND	ND	30	0		Y Off UV		Carpet; AP; hallway door open; elevated moisture content in WD carpet under drain; recommend removing WD section, low moisture content in non-WD carpeting
20	70	51	910	ND	ND	51	3		Y	Y Wall	Hallway door open; passive door vent; local exhaust vent
Portable Classroom	75	56	863	ND	ND	23	12		Y Ceiling	Y Ceiling	DEM

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Amvet Boulevard Elementary School **Indoor Air Results**

Amvet Boulevard, North Attleboro, MA 02760 **May 12, 2004**

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Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Computer Lab	74	44	1012	ND	ND	8	23		Y Off UV	N	DEM, PF
23	76	57	979	ND	ND	48	5	Y	N	Y	Hallway door open; passive door vent

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